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(54) SURFACE APPARATUS FOR HANDLING AN ELASTIC COLUMN

(71) We, INSTITUT FRANCAIS DU PETROLE DES CARBURANTS ET LUBRIFIANTS, a French Body Corporate, of 1 & 4 Avenue de Bois-Preau, 92 Rueil-Malmaison, Hauts de Seine, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to surface apparatus for handling an elastic column such as a column extending into a borehole in the ground, so that the column can be lowered into the borehole and raised back to the ground surface.

This column may, for example, be a flexible drill pipe used in a drilling process in which the usual string of rigid stems is replaced by a continuous flexible pipe at the lower end of which a down-the-hole motor is directly connected to a drill bit for actuation thereof.

It is however also possible to use the apparatus according to the invention for handling a column or any elongated member of solid cross-section lowered in a borehole, such as a cable, liable to undergo some elongation under its working conditions.

According to the present invention, there is provided a surface apparatus for handling an elastic column, the apparatus comprising at least a lower gripping device and an upper gripping device for gripping the column, operating means associated with each of the gripping devices for moving the gripping devices into and out of column-gripping positions, means for displacing at least one of the gripping devices in the axial direction of the column, means for sequentially actuating the operating means and the displacing means, the actuating means being capable in use of maintaining at least one of the gripping devices in its gripping position and causing successively the displacement in one direction of a movable gripping device or devices in an actuated condition, to raise or lower the column, the release of the said actuated gripping device or devices, and the displacement in the opposite direction of the movable gripping device or devices in a released condition, each of the gripping devices comprising a plurality of individual gripping elements arranged in series and interconnected through elastic means.

A surface apparatus according to the present invention will now be described by way of example with reference to the accompanying drawings, wherein

Figure 1 diagrammatically illustrates an overall view of drilling equipment, including the surface apparatus;

Figure 2 illustrates a gripping belt or element forming part of a gripping device;

Figure 3 diagrammatically shows an arrangement of the gripping belts or elements in each of the lower and upper gripping devices;

Figure 4 illustrates an embodiment of means for synchronously controlling the apparatus.

Referring firstly to Figure 1, drilling equipment for drilling with a flexible drill pipe 1 comprises a derrick 2 at the top of which the pipe 1 passes over a pulley 3.

The pipe 1 is stored on a winch 4 associated with means for supplying the pipe 1 with drilling fluid through a rotary coupling. Between the winch 4 and the pulley 3 the pipe 1 passes through a tension regulating device. The winch 4 and the tension regulating device 5 are however not part of the present invention.

The drilling equipment also includes an apparatus for handling the pipe 1, which comprises a lower gripping device 6 for gripping the pipe 1. The lower gripping device 6 is stationary, being integral with a substructure

7 of the derrick 2 and comprising a series of gripping belts or elements, each of which is provided with gripping jaws and with means for moving these jaws into and out of a pipe-gripping position, whereby the jaws can be reversibly displaced between a gripping position in which they grip the pipe 1 and a released position in which the pipe 1 can freely slide betwen the jaws and rigid metallic elements such as a drill bit and drill bit drive motor, which are connected to the lower part of the pipe 1, can also pass between the jaws.

In combination with the lower gripping device 6 the illustrated embodiment of the apparatus according to the invention includes an upper gripping device 8 for gripping the pipe 1. The upper gripping device 8 also comprises a series of gripping belts or elements, each of which is provided with gripping jaws associated with means for reversibly displacing the jaws in a direction transverse to the pipe 1 between a position in which they grip the pipe 1 and a position in which the pipe 1 is released. This upper gripping device 8 is movable vertically over a stroke L along the pipe when the jaws are in the released position.

In Figure 1, the means for the displacing of the upper gripping device 8 along the pipe 1 comprises a hoisting device of a kind used in rotary drilling methods for handling the drill string and its elements. The hoisting device includes cables 9 passing over a stationary pulley block 10 located at the top of the derrick (the pulley block 10 includes for example two pulleys located on respective sides of the pulley 3) and round a travelling block 11 from which the upper gripping device 8 is suspended by means of a hook 12. The travelling block 11 is displaced vertically by means of a winch 13 on which is wound a free end portion *9a* of cables 9.

The above-described conventional hoisting device can be used in the apparatus according to the invention by providing an axial passage 14 through the travelling block 11 and axial bores through the hook 12: the passage 14 and the bores are of a sufficient diameter to allow the pipe 1 to pass freely through them.

The apparatus also includes means for synchronously controlling on the one hand the means for displacing the upper gripping device 8 (winch 13 as illustrated in Figure 1) and on the other hand the means for moving the jaws of the two gripping devices 6 and 8 into and out of their gripping position.

The control means which are not shown on Figure 1 but which will be described hereinunder with reference to Figure 4, can repeatably provide for either of the following two series of operations:

I—Raising the Pipe

1) Simultaneous gripping of the pipe 1 by the jaws of the two gripping devices 6 and 8 when the upper gripping device 8 is in its lowermost position, substantially in contact with the lower gripping device 6.

2) Releasing the jaws of the lower gripping device 6, the upper gripping device 8 remaining in its gripping position.

3) Actuating the hoisting winch 13 so as to raise the upper gripping device 8.

4) Stopping the upper gripping device 8 in its uppermost position at the end of its stroke L.

5) Moving the jaws of the lower gripping device 6 into their gripping position, then releasing the jaws of the upper gripping device 8, while the jaws of the lower gripping device 6 remain in their gripping position.

6) Lowering the released upper gripping device 8 over the stroke L, into its lowermost position and stopping it in that position.

7) Moving the jaws of the upper gripping device 8 into their gripping position, in the lowermost position of the upper gripping device 8.

II—Lowering the Pipe

1) Simultaneous gripping of the pipe 1 by the jaws of the two gripping devices 6 and 8, while the upper gripping device 8 is in its uppermost position at the top of the derrick 2.

2) Releasing the jaws of the lower gripping device 6, the upper gripping device 8 remaining in its gripping position.

3) Moving the upper gripping device 8 downwardly under the load of the pipe 1, with braking of this movement, for example by means of the winch 13.

4) Stopping the upper gripping device 8 in its lowermost position.

5) Moving the jaws of the lower gripping device 6 into their gripping position, then releasing the jaws of the upper gripping device 8, while the jaws of the lower gripping device 6 remain in their gripping position.

6) Raising the upper gripping device 8 without load back up to its uppermost position and stopping it in that position.

7) Moving the jaws of the upper gripping device 8 into their gripping position, while the upper gripping device is in its uppermost position.

Figure 2 diagrammatically illustrates the structure of a gripping belt or element forming part of each of the gripping devices 6 and 8.

This gripping element includes at least two gripping jaws 15 and 16 for gripping the pipe 1, which can be brought into a pipe-gripping position by means of reversible hydraulic jacks *17a* and *17b* which are pivotally supported on a tubular housing 18. Each of the jaws 15 and 16 is formed by two superimposed wedges integral with each other.

Carried on spindles mounted on the jaws

15 and 16 are rollers 37, 38, 39 and 40 which roll along respective inclined guide paths 41 to 44 integrally carried by the housing 18.

The above arrangement of jaws 15 and 16, rollers 37 to 40 and guide paths 41 to 44 constitute a partially automatic gripping system so designed that once the jaws 15 and 16 have engaged the pipe 1, they exert on the pipe 1 a gripping action which is proportional to the downwardly directed vertical force (indicated by the arrow in Figure 2) to which the pipe 1 is subjected, as a result of friction between the jaws 15 and 16 and the pipe 1; this arrangement therefore provides a safety factor.

Each gripping element may obviously be provided with more than two gripping jaws distributed around the periphery of the pipe 1.

Inside each gripping element such as the one shown by Figure 2, the relative elongation of the pipe 1 with respect to the jaws 15 and 16 will be reduced since each gripping element only supports a fraction of the overall load supported by each of the gripping devices 6 and 8 and also because the length of the pipe 1 passing through each gripping element is only a fraction of the overall length of the pipe 1 passing through each of the gripping devices 6 and 8.

In order to permit some relative displacement without creeping of the pipe 1 between associated gripping jaws, it is advantageous to provide each jaw, such as the jaws 15 and 16, with an internal coating or shoe made of an elastomer on the internal wall of the jaw which comes into contact with the pipe 1, or to fix such a shoe to a pad made of an elastic material such as an elastomer.

This shoe may moreover be divided into a plurality of superposed elements, optionally with some clearance left between the adjacent elements.

Figure 3 diagrammatically shows a telescopic arrangement of the gripping elements forming each of the gripping devices 6 and 8. As illustrated, the gripping device comprises four gripping elements mounted in series, but this number is by no way limitative.

The number n of gripping elements in each gripping device will be selected sufficiently high so that, taking into account the coefficient of elongation of the column or pipe and the maximum load W to be supported by the lower and upper gripping devices 6 and 8, the maximum load $\frac{W}{n}$ to be supported by each gripping element will correspond to a tolerable elongation of the portion of pipe passing through that gripping element.

The tubular housing of three of the four gripping elements (housings 18*a*, 18*b* and 18*c*) is extended at its lower end as shown by a respective sleeve member (sleeve members 19*a*, 19*b* and 19*c*). Each sleeve member 19*a* to 19*c* is integral with the associated housing 18*a* to 18*c* and is designed to receive the housing of an adjacent gripping element, the housing being inserted into and surrounded by the sleeve member, thereby forming a telescopic mounting in which the housing 18 of a gripping element and the sleeve member 19 surrounding that housing are interconnected by an elastic connection, for example one or more interpolated plates of elastomer, particularly an annular coating or sleeve of elastomer (sleeves 20*a*, 20*b* and 20*c*). Alternatively, the elastic connection may comprise spring means or pack means connected to a source of fluid which is compressible under pressure to provide the "spring" effect.

The sleeves 20*a* to 20*c* are fixed to the external surface of the housing 18 and to the internal surface of the sleeve member 19, for example by vulcanization.

When the assembly of gripping element shown in Figure 3 forms the movable upper gripping device 8 (Figure 1), the housing 18*a* of the upper gripping element will be suspended from the hook 12.

An embodiment of the above-mentioned control means for synchronously controlling the hoisting winch 13 and the jacks which provide for moving the jaws into and out of their pipe-gripping position will now be described with reference to Figure 4.

Reversible jacks 21*a* to 28*a* for controlling jaws 21*b* to 28*b* of the upper gripping device 8 and reversible jacks 29*a* to 36*a* for controlling jaws 29*b* to 36*b* of the lower gripping device 6 are supplied with hydraulic fluid from a tank 45, by means of a motor-pump unit P through two slide valves 46 and 47 which are mechanically interconnected, so as to be displaceable synchronously.

This connection is diagrammatically indicated by a rod 48 in Figure 4.

An arm 49 providing for electrical contact and forming a T with the connecting rod 48 which is integral with the arm 49 provides for a synchronous control of the actuation of the winch 13 and of the jaws 21*b* to 36*b*, by closing respective electrical contacts A, O and B which are respectively connected to members 59, 60 and 61 which control the direction of rotation of the motor driving the winch 13, according to the operation to be carried out on the pipe, that is to say, raising or lowering it. The members 59 to 61 can be actuated such that:

—for the operation of raising the pipe 1, the contact A provides that the winch 13 is rotated in the direction to lift the upper gripping device 8, while the contact B provides that the winch 13 is disengaged, to permit the upper gripping member 8 to be lowered

under its own weight, with braking by the winch 13,

—for the operation of lowering the pipe 1, the contact A provides for disengagement of the winch 13 to permit the upper gripping member 8 to be lowered under the effect of its own weight and the weight of the pipe 1, with braking by the winch 13, while the contact B provides for rotation of the winch 13 in the direction of raising the upper gripping device 8. In each of these operations, the contact O provides for stopping of the winch 13.

The movements of the assembly formed by the slide valves 46 and 47 are controlled by an electromagnetically operated pilot valve 50 which, by supplying hydraulic fluid to a given one of the end faces 51 and 52 of the slide valve assembly through the conduits shown in dotted lines in Figure 4, causes the displacement of the slide valve assembly either towards the right or towards the left of the drawing.

The hydraulic circuit of Figure 4 also comprises a filter F, non-return valves 53 and 54, a pipe 55 for supplying make-up hydraulic fluid so as to compensate for losses in the hydraulic circuit (this make-up supply of fluid is for example taken from gauged oleopneumatic accumulators) and a safety valve 56.

The devices 57 and 58 are devices for regulating the flow rate of the hydraulic fluid supplied to the jacks *21a* to *36a* during the gripping or releasing movement of the jaws *21b* to *36b* respectively.

The position shown in Figure 4 of the slide valves 46 and 47 corresponds to the pipe-gripping position of the jaws of the two gripping device 6 and 8, the winch 13 being stopped (arm 49 on contact O), which corresponds to the stopping of the upper gripping device 8.

By moving the slide valves 46 and 47 towards the right of Figure 4 (which is achieved by controlling the pilot valve 50 so as to move its slide towards the left), the jaws of the lower gripping device 6 are moved away from each other, while the jaws of the upper gripping device 8 remain in their gripping position.

The arm 49 comes onto the contact A, which with the switch member 59 in the required position actuates the winch 13 to raise the uper gripping device 8.

A device which is not shown, such as an electric retarding device, may be used so that actuation of the winch 13 occurs only after opening of the jaws of the lower gripping device 6.

By moving the slide valves 46 and 47 towards the left of Figure 4, by electrically controlling the pilot valve 50, so as to displace the slide of the pilot valve 50 towards the right of the drawing, the jaws of the upper gripping device 8 are moved away from each other, while those of the lower gripping device 6 remain in their gripping position.

By electrically actuating the pilot valve 50, it is thus possible to perform the different operations, the predetermined order of which provides for the lowering or raising of the drill pipe 1.

This control may either be manual, by actuating an electrical switch (not shown) or it may be made fully automatic by using a programming device of any suitable known type, for example a drum driven in rotation at a constant speed and provided around its periphery with electrical contacts in the form of annular sectors which will successively actuate at predetermined instants which depend on their respective positions on the drum, a switch located in the immediate vicinity of the drum and actuating the pilot valve 50. This programming may also be achieved by automatic control based on the displacement of the upper gripping device 8, for example by means of photoelectric cells placed at convenient levels at the uper and lower ends of the stroke of the upper gripping device 8.

It has been assumed in the foregoing that the gripping action by each of the gripping devices 6 and 8 is performed by moving the different jaws of these devices simultaneously into their gripping position.

It will also be possible to construct the gripping means of the jaws such that the weight of the pipe 1 which is supported by each of the gripping devices 6 and 8 alternately (this weight varying moreover as a function of the unreeled length of the pipe) is taken up by moving successively into their gripping position the different gripping elements of each of the devices 6 and 8 ("de-phased" gripping), by first moving into the gripping position in each gripping device the gripping element whose displacement relative to its rest position under the effect of the load is the smallest. The gripping elements are moved out of their gripping position in the reverse order.

This will make it possible for the pipe to elongate below each gripping element, under the action of the fraction of the weight W which is supported by that gripping element and by the gripping elements which are already in their gripping position, thereby reducing the relative displacement resulting from a sliding motion or creeping or from a deterioration of the wall of the pipe within the gripping element.

In practice, since the gripping action of each gripping element becomes effective only after some time from the instant of actuation of the jacks *17a* and *17b* (semi-automatic clamping of the pipe by the jaws 15 and 16, as described with reference to Figure 2), there will be some overlapping of the periods for successively moving into their gripping posi-

tion the gripping elements of each device 6 and 8, so as to not overload any gripping element.

Assuming for example that the overall weight W is 200 tons and each of the gripping devices 6 and 8 includes four gripping elements, so that the maximum load which is to be supported by each gripping element is 50 tons, the gripping of the pipe 1 by the upper gripping device 8 in its lowermost position may be achieved by first moving into the gripping position the jaws 21*b* and 22*b* (Figure 4) of the upper gripping element of this gripping device 8 and by increasing the load supported by that upper gripping element up to about 40 tons by actuating the winch 13, after the semi-automatic clamping action has been initiated, while the lower gripping device 6 is at the same time progressively relieved of load.

The jaws 23*b* and 24*b* of the next lower gripping element are then moved into their gripping position without waiting for the jaws 21*b* and 22*b* to reach their maximum load of 50 tons.

Similarly, as soon as the fraction of the weight W supported by the assembly of the jaws 21*b* and 22*b*, 23*b* and 24*b* reaches about 50+40=90 tons, the jaws 25*b* and 26*b* are moved into their gripping position, and so on.

This method of gripping, wherein a gripping element is moved into its gripping position without waiting for the previously actuated element to reach its maximum load, results in an elongation of the pipe between these two gripping elements, with respect to its position at the beginning of the gripping action by the lower gripping element. Such elongation occurs during the above-defined overlapping period (for example when the load carried by the upper gripping element of the gripping device continues to increase from the value 40 tons, corresponding to the beginning of the gripping action of the next gripping element, up to its maximum value of 50 tons).

The arrangement of the gripping elements inside each of the gripping devices 6 and 8, as illustrated in Figure 3, permits relative displacement of the gripping elements, corresponding to the elongation of the pipe between gripping elements in their gripping position.

Various modifications may be made without departing from the scope of the invention.

For example both gripping devices may be movable in the axial direction of the pipe so that displacement of one of the gripping devices in its released position is effected during displacement of the elastic column or pipe while being carried by the other gripping device.

It is also possible, for example, to use three gripping devices arranged in series, the intermediate gripping device being stationary with respect to the drilling rig, while the upper and lower gripping devices are movable in the axial direction of the column or pipe.

It is also possible to take advantage of the semi-automatic clamping action of each gripping element by substituting single-acting jacks for the double-acting jacks actuating the gripping jaws in the embodiment of Figure 4; these single-acting jacks will release the pipe by moving the jaws away from the axis of the pipe, while elastic means will automatically move the jaws towards each other and into their gripping position when the jacks are not actuated.

The above-described apparatus may be used with conventional equipment used in conventional drilling methods, such as derricks, hoisting devices using winches, cables and pulley blocks, without requiring any substantial change in such equipment.

The apparatus may be used for handling an elastic column capable of supporting loads which may reach many hundred tons, without elongation of the column relative to the gripping device under the action of the load on the column causing damage to the walls of the column which are in contact with the gripping devices, and without creeping of the column relative to the gripping devices applied thereto.

WHAT WE CLAIM IS:—

1. A surface apparatus for handling an elastic column, the apparatus comprising at least a lower gripping device and an upper gripping device for gripping the column, operating means associated with each of the gripping devices for moving the gripping devices into and out of column-gripping positions, means for displacing at least one of the gripping devices in the axial direction of the column, means for sequentially actuating the operating means and the displacing means, the actuating means being capable in use of maintaining at least one of the gripping devices in its gripping position and causing successively the displacement in one direction of a movable gripping device or devices in an actuated condition, to raise or lower the column, the release of the said actuated gripping device or devices, and the displacement in the opposite direction of the movable gripping device or devices in a released condition, each of the gripping devices comprising a plurality of individual gripping elements arranged in series and interconnected through elastic means.

2. Apparatus according to claim 1 wherein said elastic means comprises spring means.

3. Apparatus according to claim 1 wherein said elastic means comprises jack means connected in use to a source of fluid which is compressible under pressure.

4. Apparatus according to claim 1 wherein said elastic means comprises connecting means made of an elastomer.

5. Apparatus according to claim 1 or claim 4 wherein each of said gripping elements includes a housing extended by a sleeve member for receiving the housing of an adjacent gripping element whereby a telescopic mounting is formed, and wherein said elastic means between two adjacent gripping elements comprises a sleeve of elastic material secured both to the internal surface of the sleeve member of one gripping element and to the external surface of the housing inserted in the said sleeve member.

6. Apparatus according to any one of the preceding claims wherein said gripping element includes a housing provided with means for gripping the elastic column, the gripping means including at least two gripping jaws having a gripping surface substantially parallel to the axial direction of the column, each of the gripping jaws being slidable along a guide path which is integral with the housing and which is inclined downwardly and inwardly with respect to the column, whereby the gripping jaws can be tightened on the column when the column is subjected in operation to a vertical downwardly directed tension, each of the gripping jaws being initially actuated by jack means pivotally connected to the housing and to the gripping jaw, the jack means being operative to move the gripping jaw between a position of gripping the column and a position of releasing the column.

7. Apparatus according to claim 6 wherein each of the gripping jaws is provided with at least one roller which can roll along said inclined guide path.

8. An apparatus according to claim 6 or claim 7 wherein said gripping surface of each gripping jaw is capable of partly covering the external surface of said column and has an elastomer lining.

9. Apparatus according to claim 6, claim 7 or claim 8 wherein each said jack means is operative to move the associated jaw away from said gripping position against the action of an elastic device which can automatically move said gripping jaw towards said gripping position when said jack means is not acting on said jaw.

10. A method of operating an apparatus according to claim 1 wherein in each said gripping device a first of said gripping elements is actuated to grip the column, the first element being that of which the displacement relative to its initial position as a result of the load on the column is the smallest, then the gripping element adjacent to said first gripping element is actuated when said first gripping element is substantially in its gripping position, and so on for the other gripping elements of the said gripping device.

11. A method according to claim 10 wherein the column is gripped by each said adjacent gripping element before the precedingly actuated gripping element has fully reached its gripping position, when the load supported by said precedingly actuated gripping element has reached a predetermined fraction of its final load in its full gripping position.

12. Surface apparatus for handling an elastic column, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1265420 COMPLETE SPECIFICATION

3 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

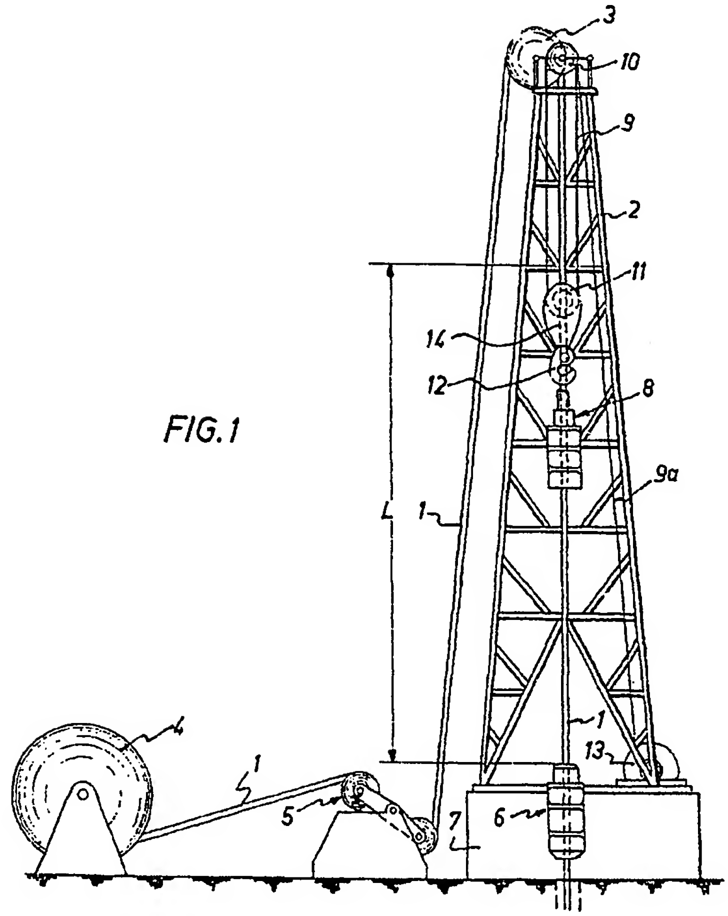
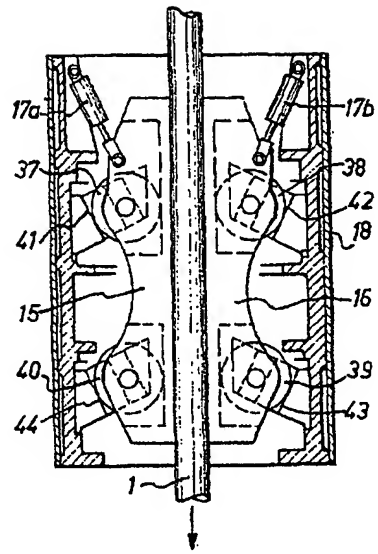


FIG.1


17a
17b
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18
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16
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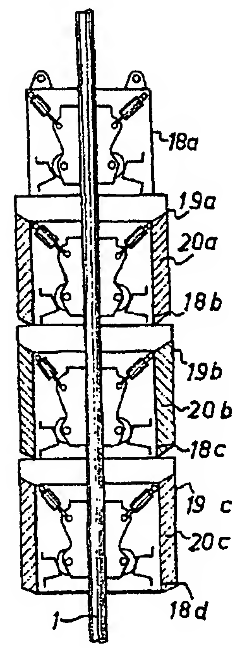
FIG. 2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18b
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20b
18c
19 c
20c
18d
1

FIG. 3

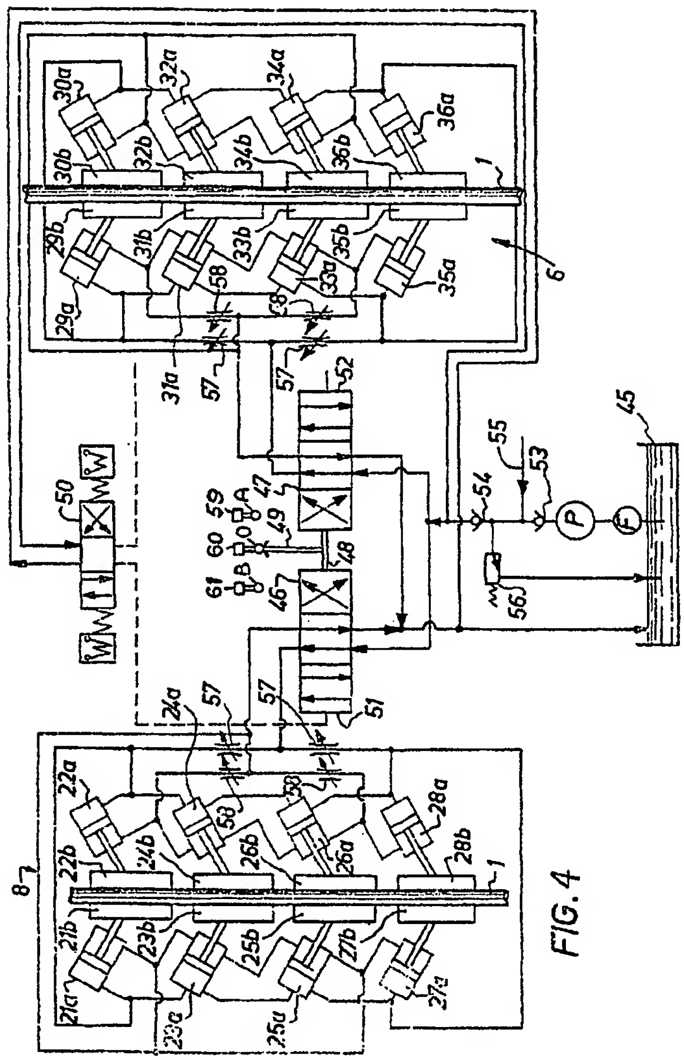

FIG. 4